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## **Putting Research Results into Use: Interrogating Knowledge Transfer Policies at the Indian Institutes of Technology**

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### **1.0 Introduction**

Over the last decade, the links between academic research institutes (ARIs) and industry, has drawn substantial research and policy attention in science, technology and innovation policy related literature. This research attention towards academia–industry relations in recent years is not just confined to academic interest *per se* but is a reflection of the importance of science and engineering as one of the sources of technical change and science based innovation in national innovation policies of developed and developing countries (Shahid and Nabeshima, 2006). A number of factors have culminated towards making ARIs in science and technology as central actors of innovation and hence potential contributor to the economy as a whole. This study on Indian Institutes of Technology (IITs) is an exploration of the different modes of knowledge transfer in the Indian context. The significance of this study is that it attempts to contribute to the body of literature on the role and place of ARIs (particularly the IITs) in the innovation system.

The paper is organised as follows: situating the IITs in context is highlighted in the first section. This is followed by a brief discussion on the theoretical perspectives guiding the study. The third section very briefly highlights the knowledge resource base of IITs. The IITs, their modes of knowledge transfer, the points of interface with industry are described in the fourth section. The next section discusses the issues relating to research results that are put to use and focuses on the empirical results of the study. The section also attempts to link the policy level issues of the institute, both organisational and institutional, that associate with the innovation process. In the last section we draw conclusions.

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## 1.1 Situating the IITs in context and adoption of 'MIT Model'

The IITs were born at a time when the Nehruvian vision clearly held that science and technology are key factor for the transformation and modernisation of India<sup>2</sup>. The Massachusetts Institute of Technology (MIT) was taken as a 'model' for setting up of IITs. There were certain features in this 'MIT model' that inspired the planners of these higher technical institutions, the prominent of which were: strong science base; course structure that integrated teaching and practical training; recognition to humanities and social science in engineering curriculum; characteristics of land-grant university committed to local/regional economic and social development; and most importantly the co-operation with industry. The vision of IITs at the time of their establishment emphasised on production of scientists and engineers of the highest calibre through *education*. It also said that education should be tightly integrated with *research* and *extension*. Over the years, there has been a shift in the vision where *research* and *innovation* now figure prominently in all the IITs. For instance, at IIT Bombay, the vision is "*to be a fountainhead of new ideas and of innovators in technology and science*".<sup>3</sup>

The study on IITs is undertaken as both theoretical and empirical investigation and is exploratory in nature of research. The theoretical underpinning to the study is mainly drawn from National Systems of Innovation', 'Triple Helix' and 'Mode 1/Mode 2' framework. The paper addresses the issues of knowledge transfer and industry interaction at ARIs and therefore the five IITs account for the sample of my study at Bombay, Delhi, Kanpur, Kharagpur, and Madras. These five IITs were visited for an *in-situ* study, interacting with faculty members, researchers, administrators and industry liaison agency personnel both through formal and informal channels. This study thus draws upon both qualitative and quantitative data. Knowledge transfer data in IITs have been analysed and examined from the year 1999-2000 to 2004-2005. Further, in many areas like intellectual property rights, publications and policy measures, we have extended the period to 2007 to have rich and consequential interpretations.

## 2.0 The Theoretical Perspectives

The 'National System of Innovation' (NSI), 'Triple Helix' and 'Mode 1/Mode 2', frameworks conceptualizes the role of academic research institutes within the innovation processes of knowledge-based economies. In 'Mode 2', there has been a conscious effort to re-look at the role of universities in a distributed and diverse knowledge production system<sup>4</sup>. In the 'triple helix' framework the interaction among university-industry-government is claimed to be the key to improving the conditions for innovation in a knowledge-based society. According to Etzkowitz & Leydesdorff (2000), the privileged actor among the three spheres is university as source of new knowledge and technology, while industry is a member as the locus of production; and government as the source of contractual relations that guarantee stable

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<sup>2</sup> Prime Minister Jawaharlal Nehru and the political leadership of independent India gave unprecedented support and policy attention to the establishment of IITs in 1940s.

<sup>3</sup> Source: Report of the IIT Review Committee (2004), Government of India

<sup>4</sup> See Gibbons et al., 1994; Gibbons, 1998 and 2003. In 'Mode 1', knowledge is generated in an autonomous university: in self-defined and self-sustained scientific disciplines and specialities, and is governed by peer group scientists who have a say in telling what constitutes science and truth and what does not. In case of 'Mode 2', knowledge particularly in science is characterised by interdisciplinarity and plurality and is no longer produced only in university settings but is also found increasingly in many different loci, like government laboratories, industries and other think-tanks and that it tends to be produced in context of application.

interactions and exchange. The NSI framework emphasizes how innovations are introduced and spread in the context of a country and attempts to explain as to why national economies differ. This concept also explains why certain actors are important to the overall dynamism in the system of innovation. Lately the NSI literature is seen to increasingly emphasise on the significant role of universities in the systems of innovation even though the focus of NSI has been on firms<sup>5</sup>. Lundvall (2002: 9), drawing upon Nelson's (1993) observation of universities being widely cited as a critical institutional actor in NSI, notes that "the universities have become more directly involved in market-driven processes and more exposed to competition from other producers of knowledge.....universities now have 'a third task' with focus on their direct contribution to a more dynamic development of the business sector".

The importance of academic research institutions gaining recognition in having a significant place in the national systems of innovation has been due to two factors. The primary reason seems obvious that academic research has the potential to contribute to innovation system in the form of technological innovations, new knowledge, novel products, services etc. The other reason is more due to the external pressures in the form of declining government monetary support, which allow academic institutions to capitalise on their research and other intellectual assets. There are numerous evidences that show such state of affairs. Cohen et al., (1998) elucidates the situation of American public research academic institutions, whilst Slaughter and Leslie (1997) explain the situation in UK, USA, and Australia. Universities throughout the OECD also have been affected by tighter constraints on public funding since 1970. Faced with slower growth in overall public funding, increased competition for research funding, and continuing cost pressures within their operating budgets during the past two decades, at least some universities have become more aggressive and 'entrepreneurial' in seeking new sources of funding (Mowery and Sampat, 2004).

IITs in this context, we presume, are putting a strong foothold in creating a knowledge research base that contributes to the innovation system. As we would see, that IITs are increasingly being seen as frontiers of science based innovations and as enterprising institutions producing highly skilled graduates as also seed-bed of new firms. The presumption draws largely from the current functioning of IITs which have a bearing on the historical developments. This also implies that the adoption of MIT model, its typical characteristics, and assistance of four nations have a notable role in supplementing the IITs as an important actor in India's innovation system<sup>6</sup>.

### **3.0 Knowledge Resource Base at IITs: Some Indicators**

While the focus of this paper is to look at the knowledge transfer environment at IITs, their research intensity is known through several pointers. During 1999-2005 period, the five IITs on an average collectively enrolled 6900 students annually, out of which one-half were post graduates, nearly two-fifth were undergraduates and a little over ten percent were PhD students. Similarly the student output from these five IITs was a little over 5400 every year. The five IITs together have around 2000 faculty members where numbers of full-professors are

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<sup>5</sup> In Lundvall's view (1988, 1992), the role of demand and supply, i.e. market forces are important in determining the rate and direction of the process of innovation and firms are largely the carriers of innovation process.

<sup>6</sup> The 'MIT model' adopted by the IIT system is seen to influence all IITs in different ways, however the assistance of erstwhile USSR and UNESCO in setting up IIT Bombay; Germany in establishing IIT Madras; USA in establishing IIT Kanpur and Britain in setting up IIT Delhi, have played a significant role in the growth of IITs (also see Sebaly, 1972).

nearly equal the total number of associate and assistant professors. The faculty: student ratio at IITs is computed to be 1:10. IITs have witnessed a gradual increase in the post-graduate and research students which has enabled them to increase their research and innovation base. There has been a near reversal in the undergraduate to postgraduate ratio at IITs in five decades of their existence. The UG: PG ratio as recommended by Sarkar Committee was 2:1 (Interim Report, 1946), which in 2004-05 was found to be 1:1.72. The PhD awardees have also increased considerably from 295 in 1986 to 660 PhDs from five IITs in 2006-07. A direct indicator of knowledge generation in ARIs is the number of publications in refereed national and international journals. There has been a significant increase in number of publications at these five IITs (from 1650 in 1999 to 3652 in 2007 as listed in the international indexing service—the SCI Expanded *Web of Science*). The five IITs have also shown a remarkable increase in the intellectual property filing. From single digit applications in early 1990s, the five IITs put together, filed 88 patents in 2006. There has been a over two-fold rise in participation of IIT personnel in both national and international conferences in a span of five years. There has also been a significant increase in sponsored research, and industrial consultancy projects: to the tune of 227% from 1999 to 2005; details of which we shall discuss in upcoming sections.

#### **4.0 Institutional and Organisational Arrangements for Knowledge Transfer at IITs**

The institutional framework, consisting of policies, practices and appropriately trained human resources, are essential for effective knowledge transfer to occur between ARIs and industry. Similarly organisational arrangements like setting up of technology transfer offices/industry liaison agencies, entrepreneurship cells and incubation units have been developed at IITs. While ARIs get direct economic benefits stemming from their involvement in sponsored research projects and consultancy assignments, from their intellectual property (protected or not); there are also high spill-over advantages germinating from the public-private collaborations in the form increased economic activity, such as start-up firms and job creation. Often the intellectual assets developed by researchers in academic institutions—their inventions, technologies and know-how—are not transferred to industry and are rarely put to any practical or commercial use such that they can be employed in activities to stimulate economic growth. However, the institutional framework necessary for transfer of technologies/know-how from academia to the private sector is not well developed in many developing countries including India. IITs as representative set of ARIs particularly in science and engineering have created such institutional arrangements, more so in the last decade for facilitating knowledge transfer.

#### **4.1 Industrial Consultancy**

Apart from teaching and research, faculty, technical staff and often students of IITs take up many assignments of direct relevance to industry. This activity is known as *industrial consultancy* and includes testing and certification of industrial products; developing prototypes and testing; exploring new approaches to design and manufacturing; designing new products; investigating or rectifying problems; offering specialized programs to industry to keep them abreast of latest developments; and assisting in technology up-gradation. Typically, anyone from industry/external agency can contact IIT for solution to any type of problem/need in any discipline of engineering, management, science and social science. The present focus of consultancy services at IITs is to expand interactions to a multidimensional mode by building

strong R&D partnerships with industry.<sup>7</sup> All five IITs have institutionalised a policy of industrial consultancy which is administered along with sponsored research.

The service contracts in the form of sponsored research and industrial consultancy (SRIC) with knowledge experts in ARIs are becoming a commonplace for industry and government. Even though many of SRIC projects are undertaken for technological developments which often lead to innovations; the advisory and consultancy services are encouraged as a means to supplement academic salaries. It is worth mentioning that IITs have institutional policies to ensure that SRIC activities do not conflict with the interests of academic freedom in an academic setting and entail procedures and guidelines elucidating the rights and obligations, legal liability and risks associated with faculty and staff involved in SRIC activities. However one should note that these channels should not be equated to revenue earnings. For instance D. Ghosh, deputy director (IIT-Bombay), observes that "...strictly speaking, sponsored research is not an income to the institute, you have to utilise the amount for that specific task or purpose"<sup>8</sup>.

#### **4.2 Mobility of Faculty to Industry and Vice-versa**

Mobility of faculty members to industry and vice-versa encourages cross-fertilization of ideas, exchange of varied experience and more importantly an effective way of knowledge transfer. In addition to policies encouraging the participation of IIT faculty and researchers in seminars and conferences, there has been a general recognition to have a greater mobility to industry and vice versa. There are recommendations made IIT Review Committees and by Knowledge Commission for increasing academia-industry interface through personnel exchange and interaction. Pitroda (2008) suggest a possibility of secondment of faculty and researchers to industry during vacations. To promote greater linkages between IITs and industry it has also been recommended that faculty should spend compulsorily one of their sabbaticals in industry<sup>9</sup>. Academia and industry need to engage in joint research to encourage innovation and competitiveness in the global economy. The Principal Scientific Advisor of Government of India has moved a proposal to allow industry to send some of the engineers, recruited during placement interviews and having talent for research, to pursue higher studies in IITs leading to PhD in the field of engineering and technology. These engineers according to him would be paid the same salary if he were holding that job for which he has been recruited<sup>10</sup>.

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<sup>7</sup> The consultancy projects are provided largely for small and medium scale industries as also for large industries; for national agencies such as department of space, defence, atomic energy, information technology and so on; for national missions, government departments, financial institutions, banking and insurance sectors and for international organisations

<sup>8</sup> Pinto V S, (2006), A 'premium' price for education, *The Financial Express*, February 18

<sup>9</sup> Report, IIT Review Committee, 1986: Recommendations of the IIT Review Committee, Chairman: Y. Nayudamma <http://education.nic.in/cd50years/f/G/J/0G0J0E01.htm>

<sup>10</sup> The IIT Review Committee (2004) has also observed the need to devise a mechanism that encourages, and rewards mobility between various sectors through a National Pension Scheme. According to the scheme, all faculty members would be eligible automatically to such a scheme where a faculty will carry a national pension record. Wherever he/she serves in segment, approved by the Council of Institutes of Technology, his/her actual service is recorded. With such a scheme an IIT faculty would be able to move freely to R&D organisation, industry, other engineering colleges and institutions. To promote greater linkages between IITs and Industry and IITs' involvement in national development projects, it is recommended that faculty should spend compulsorily one of their sabbaticals in industry

### 4.3 Industrial Consultancy to Emergence of TTOs

There have been limited studies to discuss, in any real depth, the role that an industrial liaison office (or its equivalent function within the ARI system) can play in the knowledge transfer process. The views from limited pool of experts in this area nevertheless provide much insight into the role of technology transfer office (TTO) in academic institutes, which is a rather new phenomenon in India.

According to Webster and Etzkowitz (1991) a wide range of collaborative links as well as intermediary agencies through which academic research can be commercialised have developed. Organisational innovations like technology transfer offices provide a window on academic discoveries with commercial potential and a point of contact to reach the academics who originated them (Etzkowitz, 2002). The creation of TTOs has introduced organisational changes that have created many new opportunities for technology commercialisation and have made academia-industry relationships more transparent and efficient (Graff et al., 2002). According to Rogers et al. (2000), the diffusion of TTOs in US was due to Bayh Dole Act of 1980 and due to the growth of the bio-technology and life sciences industries and their reliance on academic research and its resulting patents. Mowery et al (2001) attribute the rise in patenting due to the strengthening of U.S. intellectual property rights, during the 1980s, which resulted from a combination of judicial decisions that made life forms patentable. Academic scientists differ greatly in their interest in realising financial gains from their discoveries and in their ability to pursue the practical implications of their research. Even if they do not have a pecuniary motivation themselves, TTOs can make arrangements to protect and license discoveries on their behalf and that of institute (Etzkowitz, 2002).

In the early 1970s, in some IITs (Kharagpur and Madras), efforts were made to formalise industry interaction through research projects and consultancies and as a result industry liaison agencies were established. In other IITs, such functions were carried on by other departments (such as R&D departments) as research collaborations with industry were not many. In last two decades, as the Indian industrial growth witnessed considerable growth the demand of knowledge and know-how from ARIs such as IITs increased, and new systems have evolved (table 1).

**Table 1: The Industry Interaction Agencies/TTOs at IITs**

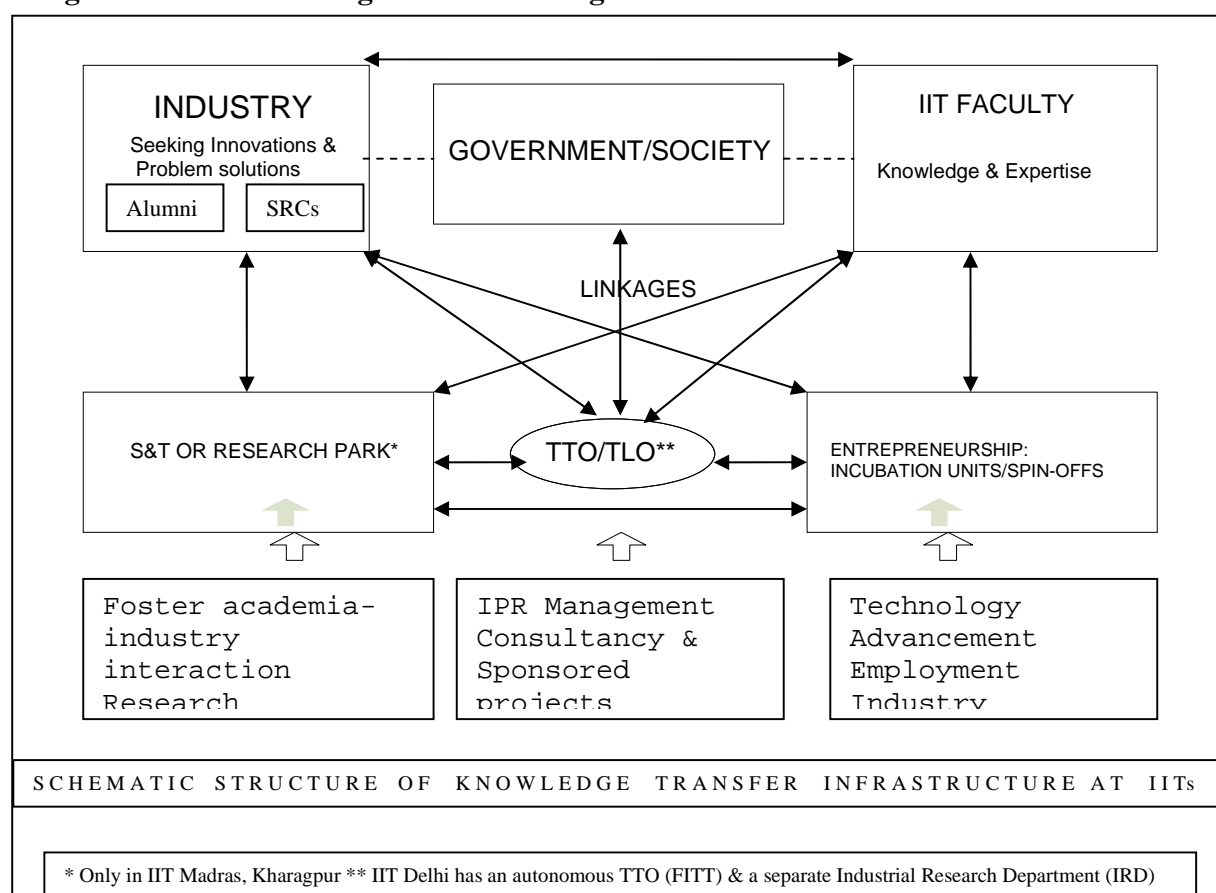
Institution	Industry liaison agency/ TTO & Year	Head/Key Personnel
IIT Bombay	Industrial Research and Consultancy Centre (IRCC); 1970s	Dean (R&D); Associate Dean; Chief Technical Officer
IIT Delhi	Foundation for Innovation and Technology Transfer (FITT); 1992	Managing Director; Executives-technology transfer; IPR
IIT Kanpur	Innovation and Incubation Centre (SIIC)*; 2001	Dean, R&D; Manager (SIIC)
IIT Kharagpur	Sponsored Research and Industrial Consultancy (SRIC); 1971	Dean (SRIC); Professor-in-charge (IPR & IR)
IIT Madras	Centre for Industrial Consultancy and Sponsored Research (IC & SR); early 1970's	Dean; Chief techno-economic officer

Source: Annual Reports (various years) and websites of respective IITs

\* Small Industries Development Bank of India collaborated with IIT Kanpur to set up SIIC

The establishment of TTOs, some of which are autonomous bodies; framing of innovation specific guidelines and policies (for instance licensing policy, revenue sharing policy, intellectual property policy); technology business incubation units are such dynamic formations that have compelled the IITs to evolve or start attempting in evolving innovation strategies (see figure 1). Here the marketing model introduced a business element into the ARIs which exemplified an aspect of the triple helix model of one institutional sphere ‘taking the role of the other’.

**Figure 1: Schematic Diagram of Knowledge Transfer Infrastructure at IITs**



IPR: Intellectual Property Rights; VC: Venture Capital; S&T: Science & Technology; SRCs: Strategic Research Coalition; TTO/TLO: Technology Transfer Office/Technology Licensing Office

The importance of having a separate unit, yet being a part of the institute has been emphasised by researchers. Some studies specifically focus on professional aspects of TTO. The skills necessary for successful technology commercialisation are largely tacit and are developed through a process of learning-by-doing (Teece, 1986). As a result these skills are not sold effectively in markets (Teece et al., 1997). According to Shane (2002), the best solution for university technology commercialisation requires that economic actors who have a comparative advantage in that activity should commercialise that technology. He notes that on the average, the inventors of university technology do not have a comparative advantage in technology commercialisation. Technology commercialisation involves a set of skills—including identifying

customer needs, developing product concepts, designing products and processes, prototyping, and manufacturing—that university inventors rarely possess. In the absence of problems in market for knowledge, the licensing of inventions to those advantaged in technology commercialisation provides a mechanism for allocating inventions to those actors who are best able to commercialise them (Teece, 1980). Debackere and Veugelers (2005) explore the role of TTOs in improving industry science links. One of the very few studies on assessing the impact of organizational practices on the relative productivity of university technology transfer offices is done by Siegel et al. (2003). This exploratory study suggests that TTO activity is characterised by constant returns to scale and that environmental and institutional factor explain some of the variations in productivity performance. Their study reveals that the most critical organizational factors are faculty reward systems, TTO staffing/compensation practices and cultural barriers between universities and firms. We shall look into the policy of revenue sharing in the upcoming sub-section 4.6. Rogers, Yin and Hoffmann (2000) assess the effectiveness of TTOs at US research universities and lay down the characteristics of universities that are relatively more effective in technology transfer namely higher average faculty salaries, a large number of staff for technology licensing, a higher value of private gifts, grants and contracts, and finally more R&D funding from industry and federal sources.

There are very few studies in India that reflect on the role of TTOs in India. Basant and Chandra (2007) observe that not all institutions seem to have an adequate knowledge base to participate in knowledge based networking activity. Moreover, only a few of these institutions have systems in place to undertake formal knowledge transfer. Mohan (2006) brings about the functioning of TTOs operating in contrasting cultures of academia and industry and further notes that TTOs in academia are not so successful. Chandra (2003) gives an empirical account of industry interaction of IIT Delhi, its technology transfers and the role of TTO. The above review of literature on TTOs shall form the basis of our discussion in the concluding section.

#### **4.4 Knowledge transfer process through TTO**

This transfer process in the IITs, which usually involves patenting and licensing, reflect a three stage technology transfer model given by Thursby and Thursby (2002). The three stages that involve multiple inputs in each stage follow a sequence of steps typically involved in licensing academia spawned inventions. Technology transfer process begins formally, when TTO receives invention disclosure from faculty or researcher. The inventors are influenced by the possibility of earning a substantial fraction of eventual royalties (Graff et al., 2002). The IIT personnel, when they sense that they have generated intellectual property that has commercial potential, they report it promptly in writing and sign the nondisclosure form. The creator agrees to assign all his/her rights in intellectual property to the institute unless specifically authorised to retain them by the competent authority. In the second stage the TTO on the select disclosures, further decides to patent and/or license the invention based on these parameters that a firm has expressed interest in asking for a license, that the invention very clearly meets the legal criteria of being patentable (novelty, non-obviousness and industrial applicability), that the technology has favourable market prospects, that the faculty has credibility and a good track record of previously marketed inventions, and that the TTO is encouraged by inventor. In making the decision to patent, it is emphasised that, despite the importance of potential earnings from the commercialisation of a new invention, the patenting process does not impinge upon the faculty inventor's overarching academic objectives (Castillo et al., 2000). Here, patenting is effectively seen as a part of university's technology marketing channel (Graff et al., 2002).



The intellectual property cell of IIT evaluates the disclosure made by the creator on the disclosure-form and within a stipulated time (normally 90 days) has to decide if the institute is willing or unwilling to own the intellectual property. It is generally observed that TTOs apply for patents when it is easy for them to find the licensees. The new patent applications are considered as a measure of second stage output as against patents awarded not only because of the substantial time lag between application filed and issue of patents, but also because patent applications are a better measure of a university's interest in commercialisation. In the last stage, the license agreements get formalised and are signed by the licensee and TTO. Typically in an IIT, the TTO on an average receives 50-60 disclosures annually and after they are screened for their novelty and industrial use they are further put up before the standing committee. This committee formally decides on funds and other resource support for R&D.

Though there has been a considerable growth in the number of disclosures of inventions by IIT faculty/researchers in the past five years, there is a need to know whether the growth in disclosures is due to a reorientation of faculty research toward the needs of industry and away from basic research, or whether the growth is due to a greater willingness on the part of researchers to disclose as well as publish the results of their research. In other words, there is a need to know if the propensity of faculty to disclose inventions has increased either because they are more willing to license as well as publish their research or because their research has shifted toward topics of more interest to industry? (Thursby and Thursby, 2002: 91) It is the latter element of faculty propensity that has been the focus of policy discussions.

#### **4.5 Licensing of Technologies and Patents**

Usually licensing agreements involve selling a firm/organisation the rights to use an ARI's inventions in return for a revenue in the form of fee usually paid in advance at the time of signing the agreement and/or annual running royalty payments that are contingent upon the commercial success of the technology in market<sup>11</sup>. This agreement entail the terms, conditions, and payments as agreed upon in the negotiations between the licensee and usually the institute's TTO. The licenses can be negotiated to be either exclusive or non-exclusive. Many researchers state that first a technology needs to be protected, and then the choice between exclusive/non-exclusive licensing should be made after finding the appropriate licensee(s). Exclusive licensing is often necessary to interest private industry. Non-exclusive licensing is more appropriate when the potential market for a technology is large enough to accommodate many firms or when there are many potential direct or spin-off applications of a technology. The term of licensing agreement depends upon the assessment of the technology in a product market that is often uncertain and thus difficult to evaluate (Feldman et al., 2002).

As a policy some of important licensing guidelines that TTOs at IITs follow on technology transfer are as follows<sup>12</sup>:

(a) TTO attempts to transfer/license the intellectual property generated in IITs to industry

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<sup>11</sup> The firms/organisations are usually required to provide ongoing evidence of their efforts to develop the academia spawned invention and ability to commercialise it. They as well report on specific performance achievement stages. These firms are also required to provide project proposal, business plan, company specific details like year of incorporation, objectives, financial strength, number of employees etc.

<sup>12</sup> Source: Official Documents: TTO/Industry Liaison agency at IIT Bombay, Delhi, Kanpur, Kharagpur and Madras

particularly those in the SME sector, irrespective of whether it is in public or private sector.

(b) The guiding policy for the know-how transfer in IITs is in favour of 'non-exclusive'. TTO is the facilitating organisation to effect know-how, transfers and ensures commercialisation in due course by the licensee so that the R&D efforts in IITs get consumed by the society. Both know-how transfer fees as well as the 'periodic royalty' payments are determinants of commercial exploitation by industry. The money considerations for the know-how transfer are arrived at through a series of negotiation involving the inventor, industry unit and TTO.

(c) Whereas inherent nature of technology is definitely a determinant of the price to be offered for transfer, this needs to be balanced appropriately with licensee's ability to invest in the development/commercialisation and the ultimate royalty return to IITs.

#### 4.6 The Policy of Revenue Sharing at IITs

One of the most important issues pertaining to transfer media is the influence of intellectual property policies. All the IITs have their own IPR policy. One of the key policies is the one that specifies distribution or sharing of revenue earnings from intellectual property of the academic institute. When any inventor(s) realises that his/her idea or invention can have (or already has) commercial potential, they get an incentive in the form of a share in the revenue earnings arising from the venture that has to be (or has been) commercialised. The sharing of royalties elucidates the fact that compensation is offered for research and collaboration efforts of the team and it is the use of those resources within the academic institute that indirectly lead to inventions. The most common formula in sharing of revenues in academic institutes is the equal sharing formula where the inventor, the department and the academic institute get 33 percent each. The other fairly common alternative is an equal 50-50 sharing between university and the inventor (Graff et al., 2002). Interestingly the sharing patterns for five IITs in this study are different (table 2).

**Table 2: Revenue Sharing Policy of IITs from Institute-owned Intellectual Property**

Institution	Revenue Sharing
IIT Bombay	Inventor(s) get a share of 70 percent while IIT Bombay receives 30 percent. This holds if the net earnings do not cross a threshold amount for any inventor.
IIT Delhi	Inventor(s) gets a sixty percent share while IIT-Delhi and FITT get twenty percent each
IIT Kanpur	For the first fixed amount, the inventor(s) get sixty-five percent share while IIT Kanpur and service account get twenty-five percent and ten per cent share respectively. As net earnings increase, inventor's share decreases and institute's share increases, service account is constant.
IIT Kharagpur	Equal distribution of proceeds to creator(s) and to IIT Kharagpur. In case of a third party involvement (funding agency), institute's and creator's respective share is calculated on the net receipts after deducting the third party's share
IIT Madras	Fifty percent of the revenue is credited to IIT Madras while remaining revenue is divided equally among inventors as per the royalty sharing agreement. Out of IIT Madras share five percent is transferred to the concerned department development fund and two percent to IC&SR overhead and balance to the institute corpus fund.

Source: Intellectual Property Policy document at the websites of respective IITs

#### **4.7 Initiatives for Entrepreneurship**

Several initiatives have been taken at IITs for promoting a culture of entrepreneurship among faculty, staff and students. Entrepreneurship is taught as a course, at the department of management studies at various IITs<sup>13</sup>. In another notable development, a dedicated school of entrepreneurship is being set up at IIT Kharagpur at an estimated investment of Rs 80 million which will provide appropriate knowledge and skills to aspiring entrepreneurs<sup>14</sup>. Separate entrepreneurship cells have also been established at IITs to imbue the IIT community comprising of faculty, staff, researchers and students with the spirit of entrepreneurship, and encourage them to take on entrepreneurial challenges. These units assist them in their efforts to launch and run business ventures. The Society for Innovation and Entrepreneurship (SINE) is hosted by IIT Bombay which also administers a business incubator. The Entrepreneurship Development Cell at IIT Delhi, Entrepreneurship Cell at IIT Kharagpur and C-TIDES: the Cell for Technology Innovation, Development and Entrepreneurship Support at IIT Madras are student focused establishments primarily to develop the spirit of entrepreneurship and provide mentorship from industry to young entrepreneurs. IIT Kanpur has set up the SIDBI Innovation and Incubation Centre (SIIC) to foster innovation, research, and entrepreneurial activities in technology-based areas (also see table 7).

#### **4.8 Joint IIT-industry centres and industry sponsored chairs**

The emergence of joint industry centres at IITs or long-term Strategic Research Coalitions (SRCs) as we may call them is lately a notable feature in the ecology of academia industry interface. These SRCs emphasise on basic and strategic research and the sponsor firm also takes the responsibility of building research laboratories and buildings in the academic institution. There are formal contracts over intellectual property rights and the research projects/processes/services involve a mutual agreement between the corporate and academic personnel. The SRCs are different from sponsored research or endowments and other traditional linkages in the sense that they involve financial support to undertake long-term strategic research and training from which the sponsoring firm is able to take new ideas for development purposes. This arrangement is unlike contract research where firms can specify in advance their requirement and academics are asked to deliver. Another crucial mode of industry-academia interaction is the industry sponsored chairs in IITs.

#### **4.9 Incubation Units**

Incubation and enterprise creation or what is known as spin-offs (we define spin-offs as companies that evolve from academic research institutions through commercialisation of intellectual property and transfer of technology developed within ARIs) has come into prominence and sharp focus in the literature on 'triple helix'. It is regarded as one of the main indicators for entrepreneurial universities. The spin-offs have been classified into direct spin-

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<sup>13</sup> For instance innovation and entrepreneurship, and business entrepreneurship development is taught at IIT Bombay; technical entrepreneurship course is offered at IIT Delhi. While corporate innovation and entrepreneurship is taught at IIT Kanpur; entrepreneurship development course is offered at IIT Madras

<sup>14</sup> Staff Reporter, *The Hindu* (2007) IIT Kharagpur to set up entrepreneurship school, *The Hindu*, Dec 29 and also in Mukherjee P (2008). IIT-K to set up school of entrepreneurship, <http://in.rediff.com/money/2008/feb/06iit.htm>

offs and indirect spin-offs (Yencken, Cole & Gillin, 2002)<sup>15</sup>. Direct spin-offs are companies that are created in order to commercialise an ARI's intellectual property while the indirect spin-offs are companies set up by IIT personnel and/or former students drawing on their experience acquired during their time spent at any of the IITs. The innovative small firms created through the spin-off process can be a source of new jobs, accelerate regional economical growth, create a new, or renovate an existing industrial base, and increase a region's competitiveness (Audretsch and Thurik, 2001). In addition to these benefits the spin-off process provides an additional option in the careers of scientist, enabling them to actively develop the technical application of their research (Corman et al., 1988). The strategy for setting up of incubation units involves the selection and recruitment of start-up technology businesses such that these ventures graduate from early stage incubation to mature firms generating resources on their own. The start-up firms in the IIT campuses are provided with fully furnished offices with computers, telecom and internet connectivity<sup>16</sup>. Apart from the physical infrastructure, the incubation units aim to facilitate networking and mentoring support through subject experts, organise showcasing events for incubatee companies and conduct training programmes which are relevant for the entrepreneurs.

#### **4.10 Research/Technology Parks**

Besides knowledge and technology successful ventures require vision, understanding of market, venture and working capital, organisation building capabilities, and managerial skills. A quality research and development ecosystem like the IITs have faculty who encompass vast knowledge and expertise, students, R&D personnel and entrepreneurs. Research/Technology Parks combine quality R&D ecosystem with the above mentioned requirements of a successful venture. A Research/Technology Park is a property-based venture that has infrastructure intended primarily for private and public research and development facilities, inhabits high-technology and science-based companies, and support services and has a contractual and/or formal ownership or operational relationship with one or more ARIs. The Park has a significant role in promoting research and development by the ARI in partnership with industry, assisting in the growth of new ventures, and promoting economic development, as also it has an important role in aiding transfer of technology/know-how and business skills between ARI and industry tenants.

IIT Madras Research Park, a recent initiative has been promoted by IIT Madras and Alumni with the mission of creating a collaborative environment between industry and academia to enable, encourage and develop cutting-edge technology and innovation that exceeds global standards. Research Park intends to leverage IIT Madras's technological capabilities to innovate and promote entrepreneurship by navigating research into ideas, developing ideas into products/processes and incubating them into ventures, and nurturing ventures into enterprises<sup>17</sup>.

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<sup>15</sup> Spin-off companies fall into a number of classes of varying importance in the institutional wealth creation process (Thorburn, 1997). The two classes that contribute directly to research commercialisation are direct research spin-off (DRSO) companies, where there are ongoing intellectual property rights and (usually) equity links between the parent research provider and the spin-off company; and the indirect spin-offs (ISO) or Start-ups, usually opportunistically initiated by university staff or students but with no IP or equity link back to the parent organisation.

<sup>16</sup> The incubator has support systems like library, meeting and conference rooms which are equipped with audio and video conferencing, pantry facilities and other shared facilities

<sup>17</sup> IITM Research Park will have a built-up space of 1.5 million square feet, one Innovation cum Incubation Centre (IIC) that will be the fountainhead of R&D and Entrepreneurship Development, three R&D Towers housing about 100 companies and

#### **4.11 Role of Government Schemes and Initiatives**

There are other modes through which IITs undertake knowledge transfer in which an intermediary external entity is involved. Some of these facilitating agencies are: National Research Development Corporation (NRDC); Science and Technology Entrepreneurs Parks (STEPs); Technology Information, Forecasting and Assessment Council (TIFAC) is an autonomous society under the DST which was established in the year 1988, following the Technology Policy Statement of 1983 and the recommendations of the Technology Policy Implementation Committee. The important programmes and plans relating to promotion of new technologies and entrepreneurs include the Technology Development Board (TDB), Home Grown Technology Programme, Technopreneur Promotion Programme (TePP), Technology Project in Mission Mode, Technology Vision 2020, Programme Aimed at Technological Self Reliance (PATSER) of DSIR and so on.

#### **5.0 Modes of Knowledge Transfer Practiced at IITs<sup>18</sup>**

Having discussed the structure and institutional/organisational factors facilitating knowledge transfer, we now discuss the empirical results. The modes of knowledge transfer and academia-industry interface as practiced and seen at IITs is described in different sub-sections:

##### **5.1 Sponsored Research and Industrial Consultancy**

In academic research institutes, sponsored research and industrial consultancy are among the most important channels for knowledge transfer. There are literary contributions on knowing the impact of knowledge transfer from academic institutions particularly by consulting, and sponsored research (Cohen et al. 1998; Mansfield 1995; Zucker et al. 1994, 2002). Ananth (2006) observes that industry-supported research is vital for better academia industry relations. In the US, there is almost 40% research support, while when compared with India and IIT as good an example as any, the figure is about 10 to 15% although it is increasing.

In all the five IITs, there has been a phenomenal increase in the value of sponsored research and industrial consultancy projects since 1999-2000 up to 2004-05. The growth has been from a little over Rs 700 million to nearly Rs 2300 million in five years or an increase of 227%. This also means that the value of sponsored research and industrial consultancy increased from 17% (1999-00) to 44% (2004-05) of the total government budget. Thus these two modes seem to be the main and important channels of knowledge transfer. The increase indicates the shift in focus of IITs towards research activities (see table 3).

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organisations pursuing serious R&D activities which would be large, medium and small industries and enterprises from India and overseas. The park also plans to have over 10000 engineers, scientists, researchers, innovators in diverse technologies. Finishing school at IIC plans to groom around 5000 new entrepreneurs in the future.

<sup>18</sup> Here knowledge transfer and technology transfer are being used interchangeably as we are addressing academic research institutes that yield technical know-how and new technology as research output for commercialisation. Knowledge or technology transfer as a concept is the movement of know-how, technical knowledge, or technology from one organisational setting to another, further the term is used to describe and analyse an astonishingly wide range of organisational and institutional interactions involving some form of technology related exchange (Roessner, in press *as cited in* Bozeman, 2000).

**Table 3: Combined Value of Sponsored Research and Industrial Consultancy Projects (SRIC)**

IITs	All values of Earnings and Grants in Rs million					
	Value from SRIC (99-00)	Government Grant to IITs in 1999-2000	Value from SRIC as a percentage of total grant (99-00)	Value from SRIC (04-05)	Government Grant to IITs in 2004-2005	Value from SRIC as a percentage of total grant (04-05)
IIT Bombay	197.6	671.5	29	380.0	1024.0	37
IIT Delhi	185.5	820.0	23	385.6	1000.0	39
IIT Kanpur	84.4	628.0	13	590.0	980.0	60
IIT Kharagpur*	121.0	1003.0	12	500.1	1050.0	48
IIT Madras	112.8	943.7	12	435.5	1100.0	40
All Five IITs	701.3	4066.2	17.2	2291.2	5154.0	44.4

\*IIT Kharagpur, grant-in-aid in (2000-01); Source: Computed from the Annual Reports of respective IITs

The combined SRIC earnings have increased from as low as 12 percent in 1999-2000 (see IIT Kharagpur and Madras) to as high as sixty percent of the total government grant-in-aid in 2004-05 (see IIT Kanpur). If we add the income from other sources (tuition fees, endowments), this share will decrease slightly, but the important thing to note is that the earnings through SRIC, technology transfers, licensing and spin-offs has seen a sizeable growth in a short span of five years and this trend is likely to continue. However one should also note that the majority of earnings are from government sponsored research projects<sup>19</sup>. The ratio of sponsored research to industrial consultancy typically in any of the above IITs is around 4:1 even though there is huge variation in different years (variation ranges from 2 to 10 at different IITs). Typically at any IIT, the share of public and private industry in seeking consultancy is evenly balanced. Based on a study by *Outlook* (2006)<sup>20</sup>, the share of government vis-à-vis private players in sponsored research projects was as high as 97% public against 3% private in case of IIT Delhi and 89% public against 11% private in case of IIT Bombay. IIT Kharagpur had 92% sponsored research projects funded by the government. In case of Industrial consultancy the same study showed 53% public sector/government backing at IIT Delhi while at IIT Kharagpur, the private sector accounted for 38% of total consultancy assignments.

Over the last five years (1999-00 to 2004-05) the average number of projects and value for sponsored research projects are shown in table 4 for each of the five IITs.

**Table 4: Sponsored Research Projects and their Value: 1999-2000 to 2004-2005 (Average)**

Value in Rs million									
IIT BOMBAY		IIT DELHI		IIT KANPUR		IIT KHARAGPUR		IIT MADRAS	
No.	Value	No.	Value	No.	Value	No.	Value	No.	Value
169	219	102	205	102	273	126	262	76	183

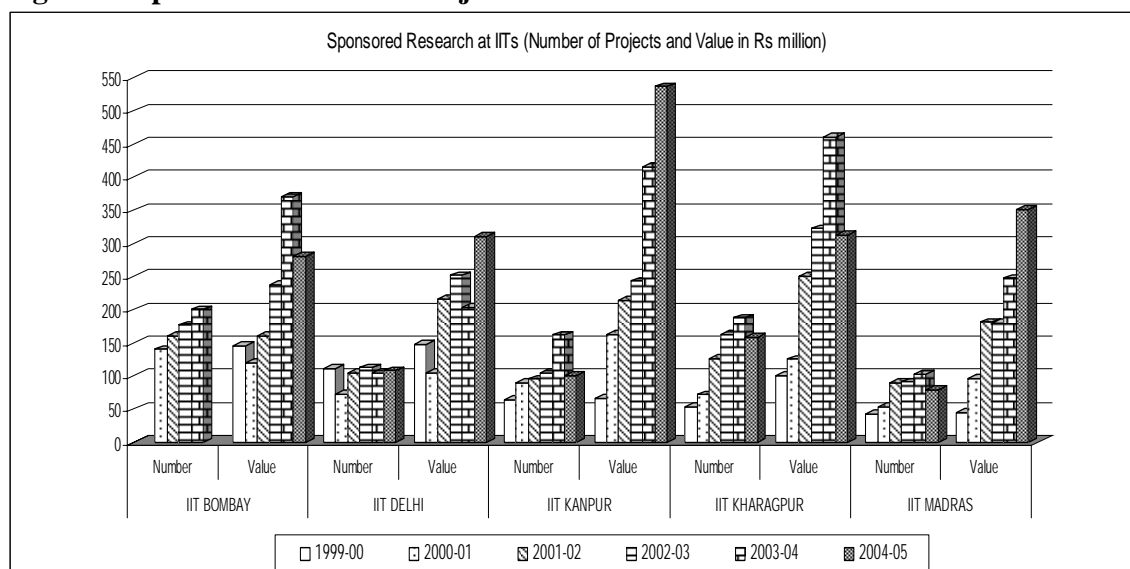
Source: Calculated after compilation from Annual Reports of IITs

There has been an overall increase in the sponsored research projects at different IITs (figure 2), which indicates that both government agencies and industry are increasingly looking towards IITs for their technological needs and potential source of innovations as well as for building trust for long-term relationships.

<sup>19</sup> These include national agencies like the Department of Science and Technology (DST), Defence (DRDO), Atomic Energy (DAE), Space (DoS), Agriculture (IARI), Medical Council (ICMR), Information Technology (MIT), Biotechnology (DBT), Council of Scientific and Industrial Research (CSIR) and so on.

<sup>20</sup> Datta, S., 2006. FITT yes, but fine?. *Outlook*. July 17: 58-64.

**Figure 2: Sponsored Research Projects and their Value at IITs**



Source: Compiled from Annual Reports of respective IITs (1999-2005)

**Table 5: Increase in Sponsored Research Projects at Different IITs**

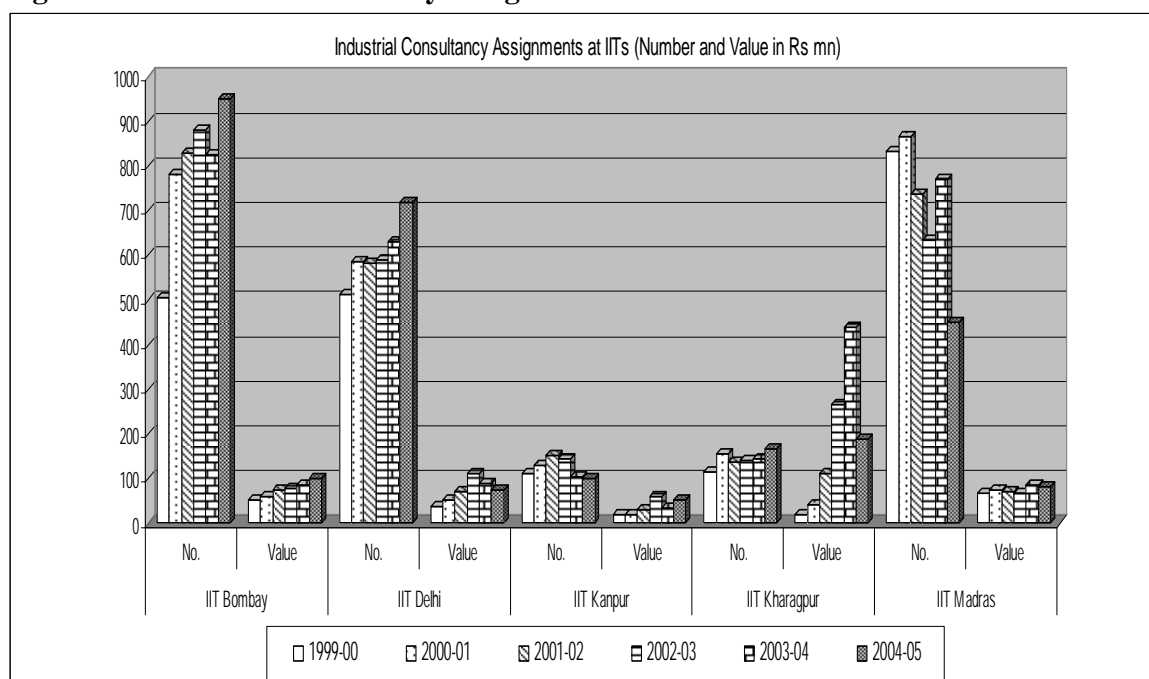
	(all values in Rs million)		
	1999-2000	2004-2005	Percentage Increase (%)
IIT Bombay	145.6	280.0	92
IIT Delhi	147.5	310.6	111
IIT Kanpur	139.1	414.9	198
IIT Kharagpur	99.7	312.4	213
IIT Madras	45.0	351.6	681
All Five IITs	576.9	1669.5	189

Source: Compiled from Annual Reports of respective IITs (1999-2005)

### Industrial Consultancy at IITs

The assignments of direct relevance to industry, offered in the name of industrial consultancy include testing and certification of industrial products; development of prototypes and their testing; exploring new approaches to design and manufacturing; helping in development of new products; investigating/problem solving; and offering specialized programs to industry and keeping them abreast of latest developments. Undertaking consultancy jobs has been an effective way of making available the expertise of the IIT personnel for the benefit of industry, government and others. Its value to IITs in stimulating further interactions and research collaborations has been well recognised, in addition to the professional and financial benefits obtained by the academics themselves. The consultancy jobs also show a significant rise at all the IITs (see figure 3 and table 6), though not as significant as in sponsored research.

**Figure 3: Industrial Consultancy Assignments at IITs and their Value**



Source: Compiled from Annual Reports of respective IITs (1999-2005)

**Table 6: Increase in Consultancy Assignments at Different IITs**

	(all values in Rs million)		
	1999-2000	2004-2005	Percentage Increase
IIT Bombay	52.0	100.0	92
IIT Delhi	38.0	75.0	97
IIT Kanpur	18.4	53.5	191
IIT Kharagpur	21.3	187.7	780
IIT Madras	67.8	83.9	24

Source: Compiled from Annual Reports of respective IITs (1999 and 2005)

The growth in consultancy has been phenomenal over the last two decades for instance in IIT Delhi in 1985-86 and in 1989-90, the total consultancy earnings were Rs 2.66 and Rs 5.5 million respectively as compared to Rs 75 million in 2004-05.

## 5.2 Industrial Research Coalitions and Sponsored Chairs

Lately we see the emergence of long-term strategic research coalitions (SRCs) at IITs (see *Appendix 1*). Most of these SRCs have been established in the emerging area of computer science and information technology. These coalitions echo the significance of basic research to industry. Some of the typical characteristics of SRCs are that they are usually single firm sponsorship of a particular research domain and have a long-term vision and duration. Whilst talking about research coalitions, we also need to mention about the sponsored chairs at IITs which play an important role in strengthening academia-industry interface. The total number of sponsored chairs in IITs increased from 46 in 1999-2000 to 53 in 2002-03 with IIT Delhi having the maximum of 25 and IIT Kanpur, the least with 3. IIT Bombay, Kharagpur and Madras had 8, 12 and 5 sponsored chairs respectively in the same period.



### 5.3 Technologies Transferred to Industry

The study shows that although there has not been considerable increase in the technology transfers in IITs, there has been a significant increase in industry participation. The increase in sponsored research projects, consultancy assignments, and patenting activities may well be indicative of a possible imminent rise in technology commercialisation from IITs. Specific disciplines are dominant at different IITs, for instance in IIT Delhi although the department of textile technology has the maximum number of intellectual property applications filed, other departments like biomedical engineering has the most cases of technology commercialisation (23%) followed by energy studies (15%) and physics (11%). Technology transfers from IITs as shown are indicative of a broader picture of technology commercialisation scenario at IITs and includes largely those technologies that were transferred or were being considered for transfer to industry. The study acknowledges its limitation for the lack of a comprehensive study on all cases of technology transfer<sup>21</sup>.

For IIT Kharagpur the prominent areas in technology commercialisation were agriculture & food (24%), metallurgy (18%) and mechanical engineering (10%). At IIT Bombay, maximum thrust on technology development and commercialisation was on mechanical (24%) and chemical engineering (17%). Likewise the focus area for IIT Madras was mechanical, metallurgy and electrical, whilst at IIT Kanpur they were mechanical, electrical and aerospace. Based on the outcomes of different cases of technology transfers in IITs it has been observed that technology transfers from IITs adopt licensing as the conventional mechanism for commercialisation, though spin-offs have started getting attention after the initiation of incubation facility in the late nineties<sup>22</sup>. Majority of licensees (about 75%) belong to small and medium sized industry category having an annual turnover of less than Rs 25 million.

The notion that patents facilitated in commercialisation of inventions was seen to be evenly balanced since most of the technologies at IITs that were transferred, were developed and did not require a lot of investment in further modification and development. However, a few firms from SME sector were seen to come forward and invest in embryonic technologies with IPR that later became successful. Interestingly, with the exception of chemistry and physics to some extent, few basic sciences appeared on the list of academic research field deemed by industry respondents to be relevant to their innovative activities. Instead, these results reflected the fact that the effects on industrial innovation of basic research findings in such areas as physics, mathematics, geology and such disciplines are realized only after a considerable lag. The study also suggests that academic research seldom produced 'prototypes' of inventions for development and commercialisation by industry. Often one technology earned substantial licensing and/or royalty income (big breakthroughs) than several small ones with

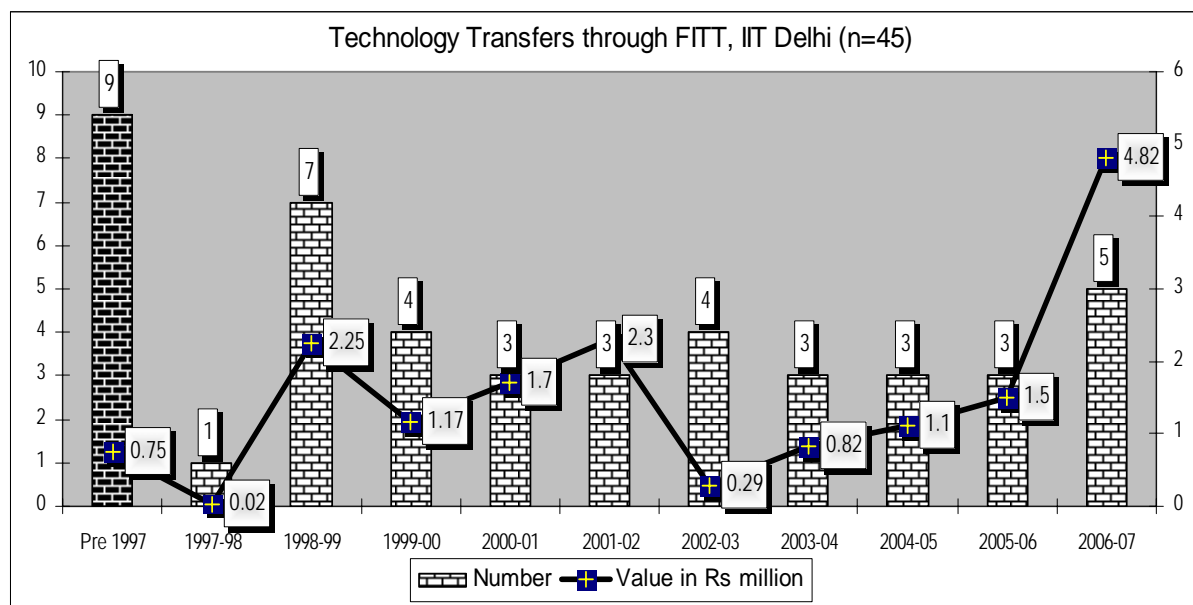
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<sup>21</sup> It would require another study to know the details about individual case of technology transfer examining several aspects like whether the technologies that were commercialised were patented; whether they obtained an exclusive or a non-exclusive license; or whether they were transferred as a consequence of a sponsored research project or an extended consultancy assignment.

<sup>22</sup> The analysis on technology transfer at IITs mainly draws from the cases at IIT Delhi, some at IIT Kharagpur and at IIT Bombay. As we have pointed out in the methodology, there were problems in collecting data on technology transfer cases from IITs at Madras and Kanpur, and to some extent at Kharagpur and Bombay.

low commercial potential. Earnings through technology transfer at one of the IITs (IIT Delhi) are shown in figure 4<sup>23</sup>.

**Figure 4: Technology Transfers from IIT Delhi**



Source: FITT Annual Reports (various years)

## 5.4 Incubation and enterprise creation or spin-offs

In our study, while IITs at Kanpur, Delhi and Bombay have adopted the conventional approach of creating formal incubation units, the spin-offs at Kharagpur and Madras have been created without the formal incubation setup. This phenomenon of enterprise creation without the benefit of formal structures may be regarded as unconventional mode of spin-off creation (Basant and Chandra, 2007). However as we will see, IIT Madras has been quite active in incubation and enterprise creation at par with other IITs. The Telecommunication and Computer Networking (TeNeT) group at IIT Madras comprises of faculty members from electrical and computer faculties who came together in 1994 with the main objective of fulfilling the socio-economic agenda of having innovations in information and communication technology (ICT) for development. The group has 15 spin-offs.

Since 2000, the spin-offs have become an integral part of the support system for the growth of knowledge based entrepreneurship particularly in the SME sectors at the five IITs (table 7). The total number of spin-off firms from all the five IITs since 1994 up to June 2008 adds to 82. These spin-offs have been set up with the primary objective to improve the entrepreneurial base and facilitate economic development. It is also a known fact that quite a few IIT graduates have done well as entrepreneurs; some of them are self-made near-billionaires (Indiresan, 2000).

<sup>23</sup> IIT Delhi where FITT is an autonomous and registered Scientific and Industrial Research Organisation brings out its own annual report unlike other IITs where data on earnings through technology transfers and other such details are not made public.

**Table 7: Incubation and Entrepreneurial Infrastructure at IITs**

Institution	Incubation Unit & Year	Incubatee/spin-offs (1994-June 2008)	Prominent Areas of Expertise of Incubatee Units	Other Entrepreneurial Infrastructure*
IIT Bombay	Society for Innovation and Entrepreneurship (SINE); 2004**	27	IT, computer science, electronics, design, earth sciences, energy & environment, electrical, chemical, aerospace	Entrepreneurship Cell
IIT Delhi	Technology Business Incubation Unit (TBIU); 1999	19	computer science, electrical , chemical, inter-disciplinary areas, life sciences, chemistry, IT, BT	Entrepreneurship Development Cell
IIT Kanpur	Innovation and Incubation Centre (SIIC); 2001	13	IT, design, weather insurance, navigation systems	Entrepreneurship Cell; Electronic & Animation Cell; Small Scale Industry Cell
IIT Kharagpur	No formal set up Technology Incubation and Entrepreneurship Training Society (TIETS)***; 2005	8	IT; computer science; ceramics; energy	Entrepreneurship Cell ; STEP; Biotechnology Park; TTG
IIT Madras	No formal set up Dynamic groups like Tele- communication Network Group (TeNeT); 1999	15	IT; computer science; physics	C-TIDES; Research Park

Source: Compiled from TTOs/Industry Liaison Agencies at IITs

IT: Information Technology; BT: Biotechnology; STEP: Science and Technology Entrepreneurs Park; TTG: Technology Transfer Group; C-TIDES: Cell for Technology Innovation, Development and Entrepreneurship Support

\* Entrepreneurship cells in IITs are largely students initiative; Technopreneur Promotion Programme (TePP) is conducted at IITs by Indian government for promoting individual innovators to become technology based entrepreneurs

\*\* An IT business incubator was set up at Kanwal Rekhi School of Information and Technology, IIT Bombay in 1999 prior to the existence of SINE

\*\*\* IIT Kharagpur is building up a formal unit-Technology Business Incubation for Innovation and Entrepreneurship (TBIIE) as a part of a grant from Department of Science & Technology, Government of India

The establishment of spin-off firms is seen as is an important commercialisation mechanism to hold and develop intellectual property where a high return is foreseen from future sales. A comprehensive analysis of the firms which have begun life within IITs, provide an interesting picture. Amongst the 82 firms examined, nearly 36 firms (44%) across the five IITs focus on IT software sector. Thus software firms appear to be dominant sector in terms of the area of operation of the firms. If we add the firms operating in the communication software (22%), 2/3<sup>rd</sup> of the total number of firms operates in the software realm. The hardware sector in both IT and communication area has about 13 firms (16%), form a distant second in terms of area of interest. This domain primarily is dominated by 9 firms operating as a part of the TeNeT group at IIT, Chennai. Firms operating in the area of energy and environment (7%) and pharmaceuticals & biotech (5%) and others (9%) constitute the rest. The following table (Table 8) presents an overview of the type of activities these firms engage in.

**Table 8: Direct Spin-offs from the five IITs**

No	Type of activities	No.
1	IT hardware	4
2	IT Software	36
3	Communication Software	16
4	Communication Hardware	9
5	Energy and Environment	6
6	Biotechnology & Pharmaceuticals	4
7	Others	7
	Total	82

Source: Author's compilation using personal interviews, annual reports, websites & newsletters of respective IITs

Individual analysis of direct spin-offs across major disciplines at each IIT is shown in figure (5a-5e). As several studies have correlated high technology firm formation with research and development intensity (Cohen and Levin, 1989; Scherer 1980), not to mention other crucial factors like capital accessibility, industrial concentration, size of the firm and such factors, there seems to be a correlation in the formation of spin-offs at IITs. For instance, the R&D activities at Kanwal Rekhi School of Information Technology (KReSIT) at IIT Bombay and at TeNet, IIT Madras have shown the maximum number of firms in IT and telecommunication. However we need to mention that the accessibility to seed capital is easier in software sector given the favourable micro and macro factors in this sector.

Figure 5a

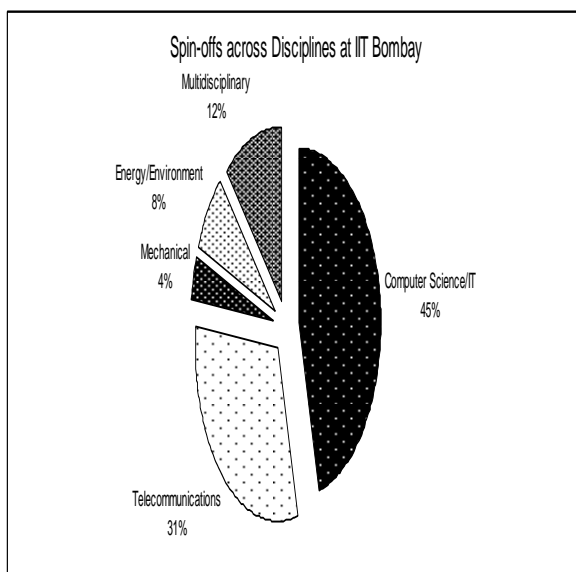


Figure 5b

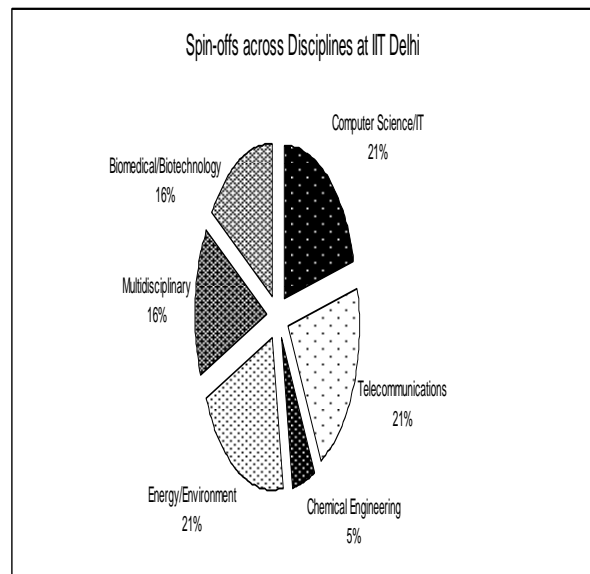


Figure 5c

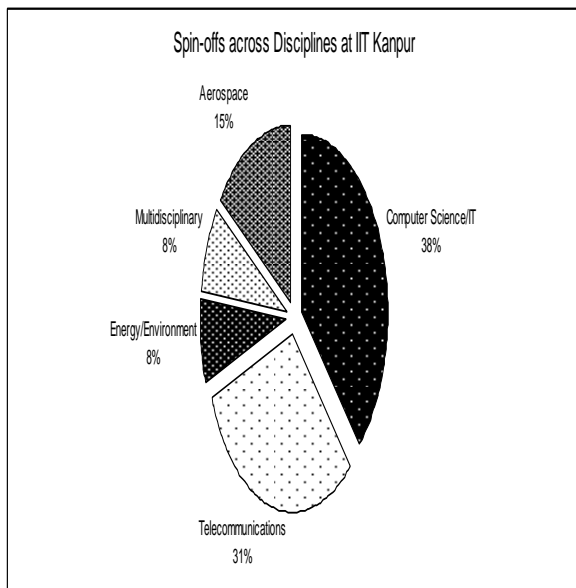


Figure 5d

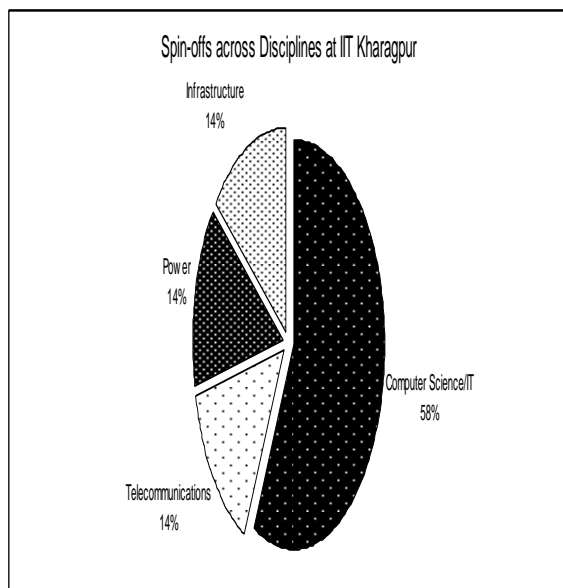
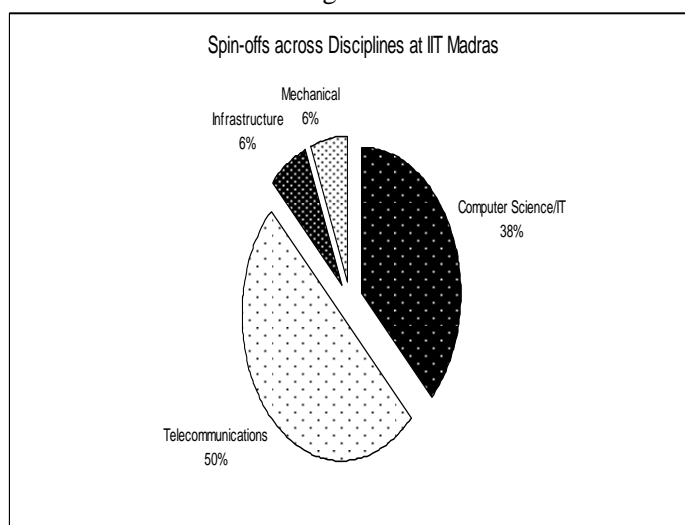


Figure 5e



Although the availability of formal incubation centres is not necessarily a contributing factor in the numbers of start-ups (as we saw in the case of IIT Madras), they do benefit the success of the spin-offs generated. The way a spin-off program is set up can significantly influence the success of the IIT in generating spin-off firms. This has been observed by Locket et al. (2003), who for instance, indicate that universities with more explicit and proactive policies towards the development of university spin-offs are more successful in generating them. Di Gregorio and Shane (2003) also show several specific areas in which university technology transfer policies can have a significant effect on new venture creation. They indicate that universities that take up equity investments in spin-offs instead of high royalties for their property rights increase the formation of these firms.

Out of the four stages identified by Vohora et al. (2004) on the process of the spin-off formation—namely the research phase, the opportunity framing phase, the pre-organisation, and the re-orientation before reaching onto the next stage—it is the last stage where the spin-offs at IITs had the maximum difficulty. In this stage which again comprises of four phases: opportunity recognition, entrepreneurial commitment, threshold of credibility and threshold of sustainability, the entrepreneurs need for funding was seen to be linked to various factors that could provide them seed capital.

In IITs, it has been noted that during the last 6-7 years, the numbers of spin-off firms outnumber the numbers of licensing agreements every year and so is the revenue generated (on an average 3-5 firms are formed as against 2-3 technology transfers from a typical IIT annually). This result is similar to what we saw in the study by Bray and Lee (2000) who observe that spinning-out is a far more effective technology transfer mechanism compared to licensing, as it creates 10 times higher income, and thus argue that license positions are only taken when technology is not suitable for a spin-off firm. The comparative picture of prominent TTOs at USA and UK vis-à-vis IITs is shown in table 9.

**Table 9: Performance Indicators of TTO/TLO in US & UK ARIs vis-à-vis IITs (2005)**

TTO/TLO affiliated to the Institute	No. of TTO staff	No. of invention disclosures	No. of new patents Filed	No. of start-ups	No. of Licenses granted	Gross Revenue
MIT	30	512	312	20	74	\$ 46 million
Stanford University	21	433	76^	12	84	\$ 48 million
University of Cambridge	30	127	41	3	40	£ 4.3 million*
Oxford University	36	141	55	4	38	£ 2.7 million#
A Small US research university	1	3	6	-	2	\$25000
Typical IIT	8	60	16	3	3-4	Rs 3-5 million
All five IITs	35-40	300-325	88**	13-15	15-20	NA

\* Licensing Revenue of £ 2.71 million and Consultancy Earnings of £ 1.58 mn; \*\* Year 2005-06

^ U.S. Patents only; # Sales Turnover in 2005; University of Oxford, Oxford; Source: <http://www.isis-innovation.com/documents/IsisAnnualReport2005.pdf> as accessed on April, 04, 2008

## 6.0 Discussion and Concluding Remarks

Over the last six decades, IITs have grown as India's eminent science and engineering institutions and have acquired recognition in imparting quality higher education. Even though the ability to produce highly skilled 'human capital' is well known, the involvement of IITs in making use of their intellectual assets for economic development and also for generating revenue has gained considerable attention only in the last one decade or so. IITs have thus become a significant part in the Indian national innovation system in terms of both knowledge production and knowledge transfer. The relevance of MIT model for IITs can be said to have close links with such development.

Our exploration has identified that there are primarily three modes of knowledge transfer at IITs: the first is the so called 'traditional' form of knowledge transfer comprising of sponsored research, industrial consultancy, training of industry/government personnel, and such activities. This mode seems to dominate and figure as the most preferred route for knowledge transfer. This mode has been by far the most successful mode as it involves many faculty members and researchers at IITs<sup>24</sup>. The growth in sponsored research and industrial consultancy (SRIC) has been substantial if we look at the combined value of SRIC projects: from a little over Rs 700 million to nearly Rs 2300 million in five years or an increase of 227%. This also means that the value of SRIC as a percentage of the total government grant to IITs increased from 17% (1999-00) to 44% (2004-05). More importantly many of the sponsored research projects are such that if they are extended for commercial potential, they find relevance in the linear model of innovation.

The second mode is the transfer of know-how or technologies/novel products and services through the formal channel where TTO plays an integral role or informally through the

<sup>24</sup> As per our study, taking into account the number of faculty involved in consultancy projects across departments from 1999 to 2005, for instance, in IIT Madras there were more than 70% faculty involved in industrial consultancy in departments such as ocean engineering, composite technology centre, civil engineering and applied mechanics. Similar is the case with sponsored research at IIT Madras where the composite technology centres, department of physics and metallurgy have over 75% faculty/researchers involved in such projects.

own initiatives of the inventor(s) at IIT (here patenting and/or licensing are qualifiers). In this mode the enabling environment for innovation is achieved through external agencies like technology transfer companies, various schemes (mostly government like TIFAC, TDB) and venture capital organisations. It has been found that commercialisation of technologies at IITs through licensing of technologies and patents do take place but they are limited in number. This is directly related to the low number of invention disclosures the TTOs receive which typically in an IIT is around 60 annually. Role of TTOs has been discussed in the upcoming paragraphs.

The third mode of knowledge transfer is through building an entrepreneurial culture and through incubation units and spin-offs. The direct spin-offs are on the rise at all the five IITs. Since 2000 the five IITs have shown a notable rise in the number of spin-offs coming out of their campuses (in all 82 spin-offs till February 2008). This lends support to our presumption that the IITs are more likely to adapt the spin-off route to commercialisation of R&D knowledge transfer than the mode of licensing and royalty earning. Also, the indirect spin-offs through IIT alumni have made colossal contribution to the teaching and research infrastructure at IITs as well as to the economy and society.

Examining technology commercialisation at IITs, the study observes that rarely do the research outputs take the form of 'prototype' so that it may be developed further and commercialized. It was observed that the technologies/patents were seen to attract very small license fees and were seen to be transferred mostly to small and medium enterprises. The barrier to this traditional form of knowledge transfer was also seen in erratic payments—the terms of which are narrowly bound between lump-sum and running royalties, with returns from former were relatively found to be certain.

The other typical functions of a TTO apart from patenting and licensing that of finding an industry partner, looking for seed capital, writing a business plan, making provisions to make use of institute's facilities and so on are no doubt important but as has been pointed out by the IIT Review Committee Report (2004: 124) an agency with adequate autonomy both financial and administrative—similar to FITT at IIT Delhi has certain advantages over an internal cell completely within the system. The review report further says that in an autonomously governed industry-interface foundation the relationships between the user agencies and the institution can be managed with greater flexibility. Because of its autonomous character, it does not depend on the IITs for budget support other than the initial seed fund for establishment and is able to obtain finances from wide-ranging sources. Furthermore, the autonomous centre can appoint non-academic professionals without burdening the institution which allows better business development and interface with industry.

We also need to specifically note that TTOs at MIT and Stanford are operating at a higher professional level or threshold in the sense that they have trained technology transfers officers/personnel with organisational capacities for locating potential industrial clients. They have over the years fully established the TTOs and operate in an environment where venture capital and other small business initiative schemes of government exist. This is not the case with IITs which are managed by a small number of personnel and the innovation ecosystem is still underdeveloped compared to MIT and Stanford cases. This is also a contributing factor for the weak role of TTOs in case of IITs. The role of TTO at IITs is seen to focus more on SRIC activities (with the exception of IIT Delhi where IRD plays a larger role). Thus, in view of the organisational culture and practice at IITs, as also the professional aspects of a traditional TTO

(as explained by Shane, 2002; Teece, 1980), it appears that the establishment of TTOs as an intermediate agency internally without much autonomy and having a pecuniary motivation is unlikely to play a significant role as a mode of knowledge transfer at IITs.

Thus the recent institutional arrangements like IP policy, technology transfer guidelines, policy of entering into strategic research coalitions with various industrial clients etc. on the one hand; and establishment of TTOs, patent cells, incubation units etc on the other; lend support to the emergence of entrepreneurial university, though in nascent form compared to MIT or Stanford cases. However despite such indicators it is improper and too early to suggest that IITs are emerging as entrepreneurial university. IITs are a special case in knowledge production and transfer modes compared to other universities<sup>25</sup>. There are reasons to believe that IITs have carved their niche in knowledge production and knowledge transfer.

In short, the paper attempts to show that while IITs recognize the importance of open science, as evidenced by the still substantial reliance on publications and consulting, they are also tuned towards the changing milieu in academia-industry-government relations. Here we observed that though the relevance of linear model of innovation is undeniable, a shift towards more direct and tightly coupled co-evolutionary models of knowledge transfer is also discernible. We attempted to establish that, in the Indian context, the third mode of knowledge transfer identified in this study through entrepreneurial infrastructure and spin-offs is unique to the IITs and very few ARIs (in view of over 350 universities in India), have succeeded in this domain. It is not the focus of this paper to suggest that the IITs are emerging as entrepreneurial universities in line with MIT (Etzkowitz, 2002) but only to argue that IITs are a special case, in their ability to establish a series of knowledge production and transfer modes as compared to other universities and that they do occupy a significant place in the Indian education, science & technology and innovation system.

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<sup>25</sup> Traditionally the role of universities in India has been limited to education and training. In some cases these lines are blurring, especially (or perhaps uniquely) in the case of the Indian Institute of Science (IISc) in Bangalore and the network of seven Indian Institutes of Technology (IITs). But R&D in universities is still very limited (Bound et al., 2006)



### Appendix 1: Prominent Strategic Research Coalitions at IITs

Location	SRCs at IIT	Research Domain
IIT Bombay	Xilinx FPGA Laboratory (2004)	FPGA Technology Field-Programmable Gate Array
	Tata Infotech Laboratory	Computing & Communication technologies; Information Technology
	Intel Microelectronics Laboratory	Microelectronics
	Tata Consultancy Services (TCS) Laboratory (2000)	VLSI Design and Device Characterization
	Laboratory for Intelligent Internet Research (TCS)	Internet, web architecture
	Texas Instruments Digital Signal Processing (TI-DSP) Laboratory	Digital Signal Processing
	Wadhvani Electronics Laboratory (2001)	Electronics
	Cummins Engine Research Laboratory (2004)	Internal combustion engines, renewable energy - alternate fuels
IIT Delhi	IBM Solutions Research Centre	Computer Science, IT
	NIIT- Centre for Research in Cognitive Systems	Computer Science, IT
	Tata Infotech Research Centre	IT
	Intel Technology Lab	Computer Science
	Microsoft Advanced Technology Lab	Computer Science
	Philips Semiconductors VLSI Design Lab	Integrated Circuits - VLSI
IIT Kanpur	Samtel Centre for Display Technologies (2000)	Display Technologies
	Prabhu Goel Research Centre for Computer and Internet Security (2003)	Computer security
	BSNL Telecom Centre of Excellence	Telecommunications
IIT Kharagpur	OPTEL - IIT Optical Fibre R&D Centre	Communications
	Post Harvest Technology Centre	Agriculture
	Space Technology Centre	Space Technology
	Micro-electronics Research	Microelectronics
IIT Madras	General Motors-Collaborative Research Laboratory	Electronics, Controls & Software
	Automotive Research Centre	Automobile
	Microsoft Laboratory	Computer Science, Electrical Engineering; Embedded Windows technology
	IBM Centre for Advance Studies	Computer Science
	Tata Consultancy Centre of Excellence in Computational Engineering	Combination of computing technology with applied engineering disciplines

Source: Websites and Annual Reports of respective IITs

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